REMARKS

Claims 1-14 are pending in this application. Applicants have amended independent claim 1 to clarify the nature of the invention and to include the limitations previously recited in dependent claim 2 and, accordingly, have cancelled claim 2. Applicants have also amended claim 3 to include the limitations previously recited in claim 4 and, accordingly, have cancelled claim 4. Additionally, Applicants have amended claims 5, 6, 7, 9, 11, and 12 to clarify the nature of the invention and for concordance with the amendments made to claim 1. Finally, Applicants have amended independent claim 13 in order to clarify the features recited in that claim. Applicants respectfully request reconsideration and allowance in view of the above amendments and the following remarks.

Claim Rejections Under 35 U.S.C. § 112

Claims 1-12 are rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicants regard as the invention. Applicants respectfully submit that this rejection is overcome by the above amendments and therefore request that the rejection be withdrawn.

Claim Rejections Under 35 U.S.C. § 102 and 103

Claims 1-13 are rejected under 35 U.S.C. § 102(a) as being anticipated by, or in the alternative under 35 U.S.C. § 103(a) as being obvious over, EP 849 591. Applicants respectfully traverse this rejection.

The present invention relates to a gas concentration sensor in which a microcomputer is used to process signals produced by the sensor element in response to the concentration of NOx, HC, and CO. The sensor according to the present invention may, for example, be used in the exhaust system of a motor vehicle. Since NOx, HC, and CO gases are present in very

small amounts in motor vehicle exhaust -- *e.g.*, NOx is typically present in concentrations of 0-2000 parts per million -- the sensor output is commensurately very small (*e.g.*, on the order of 5-10 μA of current). See page 2, lines 9-14 of the Specification.

Given the low current output of the sensor element, electrical noise or other interference generated by the electrical and mechanical systems of the motor vehicle can prevent the gas sensor from reporting accurate gas concentrations. Using a microcomputer as the signal processing component for the gas sensor as recited in claim 1 significantly improves the sensor's ability to filter out unwanted electrical noise and to amplify only the desired portions of the output signal. Claim 1 further recites that the microcomputer is disposed within a connector that is used to connect the sensor to external devices. Such location of the microcomputer is advantageous in that it reduces the amount of error introduced by the wiring itself (i.e, signal loss due to the resistance of the wire).

The claims depending from claim 1 recite other advantageous features of the invention. For example, claim 3 describes an embodiment in which the microcomputer includes an impedance measuring circuit and controls the gas sensor's heater "as a function of the measured impedance." Typically, that measurement and control function is performed by the central processing unit (CPU) of the engine, which increases the processing load placed on the engine CPU and which increases the amount of error in the sensor signal (because the signal line between the gas sensor and the engine CPU is relatively long). By controlling the heater using the gas sensor's microcomputer, which is right near the sensor, per se, the processing load on the engine CPU is reduced and error caused by the otherwise relatively long signal line between the sensor and the engine CPU is also reduced.

Dependent claim 5 recites that the microcomputer itself communicates with the engine's CPU using serial communication. This type of communication uses at most two

signal lines (i.e., two wires) and therefore conserves space, is easy to install and maintain, and introduces relatively little noise into the transmitted signals. In contrast, typical prior art sensor communication arrangements use many signal lines and therefore require many signal wires between the engine CPU and the sensor, which wires takes up valuable space inside the motor vehicle and is a potential source of electrical noise.

Newly presented dependent claim 14 recites that the microcomputer controls the first and second cells of the gas sensor using a map, such as a gain/offset map. (See page 24, lines 15-24 of the Application). Using such a map simplifies the calculation and adjustment of the various parameters of the current amplifiers that are used to amplify the output signal from the gas sensor.

Neither EP 849 591 nor any of the other prior art references of record teaches or suggests the claimed features of the present invention -- particularly the use of a microcomputer to control a gas sensor. Rather, to the contrary, EP 849 591 discloses a conventional gas sensor in which analog circuitry is used to control the gas sensor and to amplify the sensor's outputs. Furthermore, the analog circuitry disclosed in EP 849 591 does not provide the advantageous features of the microcomputer that are recited in the claims. Accordingly, Applicants submit that the present invention is not anticipated by EP 849 591.

Moreover, with respect to the alternative rejection under 35 U.S.C. § 103, Applicants submit that there would have been no motivation to modify EP 849 591 to include a microcomputer. In particular, at column 28, lines 30-36, EP 849 591 specifically touts the simple analog circuits as part of the solution to prior art difficulties:

> The system of the present invention can be realized by using simple components, for example, differential amplifiers, rectifying circuits based on the use of diodes and first-order CR low-pass filters. Thus it is possible to effectively simplify the circuit arrangement and effectively reduce electric power consumption.

(Emphasis added.) Therefore, Applicants submit that the features of claims 1-13 would not have been obvious over EP 849 591, and accordingly, Applicants request that the rejection be withdrawn.

Claims 1-13 are also rejected under 35 U.S.C. § 102(a) as being anticipated by, or in the alternative under 35 U.S.C. § 103(a) as being obvious over, EP 120 423. Applicants respectfully traverse this rejection. EP 120 423 discloses a gas sensor that is generally equivalent in function to that disclosed in EP 849 591. In particular, although EP 120 423 does use the term "microcomputer" throughout to describe the control elements of the sensor, the disclosed "microcomputer" appears to be nothing more than a set of analog circuits formed on an integrated circuit chip.

The actual characteristics and function of the so-called "microcomputer" in EP 120 423 are made clear in the Specification. For example, page 10 of the EP 120 423 reference describes the construction of the control elements: "A sequencer 500 for controlling the λ-detection circuit, pumping circuit 300, and heater 400 is connected to the individual circuits and also to the source terminals [such that] all of the circuits 200, 300, 400 combine with the sequencer 500 to constitute an IC substrate." Each of these circuits is then further described in terms of analog circuit components.

The microcomputer of the present invention, in contrast, operates in an entirely different manner. As shown in Figure 7, and as described at pages 15-18 of the Specification, the microcomputer of the present invention has a central processing unit coupled to a number of analog-to-digital (A/D) and digital-to-analog (D/A) converters. The central processing unit is software programmable and can be loaded, for example, with the program instructions

illustrated in Figures 8 and 9. Whereas the so-called "microcomputer" of EP 120 423 functions by using conventional analog signals, all of the signals processed by the true microcomputer of the present invention are converted into digital form by the A/D converters. In further contrast, the analog "microcomputer" of EP 120 423 is not programmable and does not use digital signals for signal processing. Moreover, EP 120 423 neither teaches nor suggests the use of a microcomputer according to the present invention. For at least the above reasons, Applicants submit that claims 1-14 are patentable over EP 120 423 and respectfully request that the rejection be withdrawn.

Finally, claims 1-13 are rejected under 35 U.S.C. § 103(a) as being unpatentable over EP 849 591 in view of EP 120 423. This rejection is respectfully traversed. As explained above, both of those references rely on analog circuitry for control of gas sensors, and neither of those references teaches or suggests the use of a microcomputer according to the present invention. Therefore, Applicants submit that the asserted combination of EP 849 591 in view of EP 120 423 does not yield the claimed features of the present invention, and accordingly, Applicants respectfully request that the rejection be withdrawn.

In view of the foregoing, Applicants submit that all claims are in condition for allowance, and timely notice to that effect is respectfully requested.

Respectfully submitted,
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Enclosure: Appendix

APPENDIX

Version with markings to show changes made

The claims are amended as follows:

1. (Amended) A gas concentration measuring apparatus comprising :

a gas concentration sensor having a sensor element outputting a signal as a function of concentration of [a given component of gasses] at least one of NOx, HC, and CO ;

a [signal processing circuit] microcomputer disposed within a connector configured to connect the microcomputer to an external device; [processing the signal outputted from said gas concentration sensor to produce a voltage signal indicative of the concentration of the given component of the gasses;] and

a conductor electrically connecting said gas concentration sensor and said [signal processing circuit] microcomputer for transmission of the signal from said gas concentration sensor to said microcomputer; [the conductor having a length which is determined as a function of a level of the signal outputted from said gas concentration sensor, the weaker the level of the signal, the shorter the length of said conductor.]

wherein the microcomputer is configured to process the signal outputted from said gas concentration sensor to produce a voltage signal indicative of the concentration of said at least one of NOx, HC, and CO.

3. (Amended) A gas concentration measuring apparatus as set forth in claim 1, [further comprising] wherein said microcomputer includes an impedance measuring circuit measuring an impedance of [a] the sensor element of said gas concentration sensor[, said impedance measuring circuit being integrated in a single unit together with said signal processing circuit] and said microcomputer controls a power supply to a heater which heats

the sensor element, said microcomputer controlling said power supply as a function of the measured impedance.

5. (Amended) A gas concentration measuring apparatus as set forth in claim 1, wherein the gas concentration measuring apparatus is mounted in a vehicle, [and wherein the weaker the level of the signal is, the shorter a distance between said gas concentration sensor and said signal processing circuit] and wherein said microcomputer outputs said signal to a vehicular engine electronic control unit by serial communication.

6. (Amended) A gas concentration measuring apparatus as set forth in claim 1, wherein said [gas concentration] sensor element includes a first cell responsive to application of a voltage to discharge oxygen contained in the gasses outside said gas concentration sensor, producing a first electric current as a function of concentration of the discharged oxygen and a second cell responsive to application of a voltage to produce a second electric current as a function of concentration of a specified gas component contained in the gasses from which the oxygen is discharged by the first cell.

7. (Amended) A gas concentration measuring apparatus as set forth in claim 1, wherein said [signal processing circuit has a function of compensating] microcomputer compensates for [a] unit-to-unit variation in [characteristic] the characteristics of said gas concentration sensor.

8. (Amended) A gas concentration measuring apparatus as set forth in claim 7, wherein said [signal processing circuit] microcomputer corrects an output characteristic of said gas concentration sensor so as to agree with a desired one.

9. (Amended) A gas concentration measuring apparatus as set forth in claim 3, wherein said impedance measuring circuit [has a function of compensating] compensates for [a] unit-to-unit variation in [characteristic] the characteristics of said gas concentration sensor.

11. (Amended) A gas concentration measuring apparatus as set forth in claim 4, wherein said heater control circuit is connected to said heater through a power supply conductor for supplying the power to said heater, said heater control circuit [having a function of] minimizing an error component caused by a resistance value of the power supply conductor.

12. (Amended) A gas concentration measuring apparatus as set forth in claim 1, further comprising an impedance measuring circuit measuring an impedance of a sensor element of said gas concentration sensor, a heater [heating up] which heats a sensor element of said gas concentration sensor, and a heater control circuit which controls a power supply to said heater, and wherein said [signal processing circuit] microcomputer, said impedance measuring circuit, and said heater control circuit are formed on a bare chip mounted on a ceramic substrate.

13. (Amended) A gas concentration measuring apparatus comprising:

a gas concentration sensor outputting a signal as a function of concentration of [a given component of gasses] at least one of NOx, HC, and CO;

a [signal processing circuit] microcomputer disposed within a connector configured to connect said microcomputer to an external device, said connector having one end connected

to said gas concentration sensor and another end connected to the external device;

[processing the signal outputted from said gas concentration sensor to provide a voltage signal indicative of the concentration of [the given component of the gasses;]

[a connector having disposed therein said signal processing circuit, said connector having a first end coupled to said signal processing circuit and a second end providing electrical connection with an external device to transmit the voltage signal to said external device]

wherein said microcomputer processes the signal outputted from said gas concentration sensor to produce a voltage signal indicative of the concentration of said at least one of NOx, HC, and CO.